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AUTHOR Andersen, Lorri
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ABSTRACT

This instructor's guide contains materials needed to teach a two-lesson unit on the structure and components of facultative lagoons, the biological theory of their operation, and factors affecting their operation. Control testing recommendations, maintenance guidelines, and troubleshooting hints are also provided. These materials include: (1) an overview of the two lessons; (2) lesson plans; (3) lecture outline (keyed to a set of slides which accompany the unit); (4) student worksheet (with answers); and (5) two copies of a final quiz (with and without answers). The first lesson is a review of microbiology, components, and operational modes. The second lesson covers process control, maintenance, and troubleshooting. (JN)

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Biological Treatment Process Control

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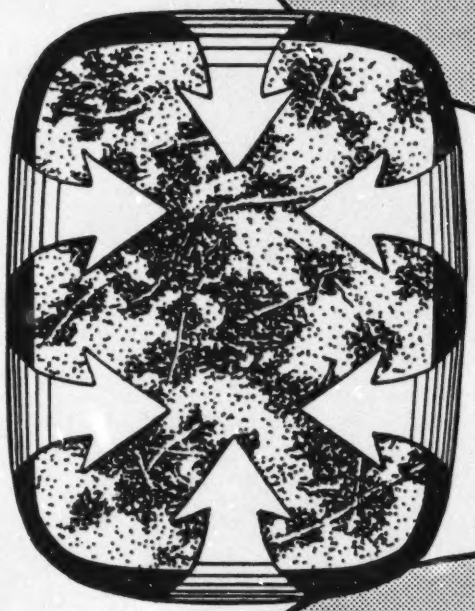
Facultative Lagoons



Instructor's Guide

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BIOLOGICAL TREATMENT PROCESS CONTROL

FACULTATIVE LAGOONS

INSTRUCTOR'S GUIDE

Text Written By:
Lorri Andersen
Envirotech Operating Service
San Mateo, California

Edited By:
John W. Carnegie, Ph.D.
Project Director
Linn-Benton Community Colelge
Albany, Oregon

Instructional Design By:
Priscilla Hardin, Ph.D.
Priscilla Hardin Instructional Services
Corvallis, Oregon

Developed Under:
EPA Grant #T901238
1984

FACULTATIVE LAGOONS

Instructor's Guide

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FACULTATIVE LAGOONS

Overview of Lessons

This unit on facultative lagoons covers the structure and components, the biological theory of operation, the factors affecting operation, control testing recommendations, maintenance guidelines, and troubleshooting hints. This unit is divided into two lessons. Lesson I is a review of microbiology, components, and operational modes. Lesson II covers process control, maintenance and troubleshooting. Both lessons are accompanied by 35 mm slides.

Lesson Plans

Lesson I
- Microbiology, Components, and Operational Modes
- Have students read text material ahead of time if possible.
- Lecture from outline with slide support (40 - 45 min).
- Explain calculation of organic loading rate and seepage rate on chalk board or with overhead (15 - 20 min).

Lesson II
- Process Control and Maintenance
- Assign text material ahead of time if possible.
- Lecture from outline using slide support up to slide #2.25 (30 min).
- Present math calculations on chalk board or overhead (15 - 20 min).
- Return to lecture from outline at slides #2.26 (15 min).
- Assign worksheet (20 - 25 min).
- Correct and discuss worksheet (20 - 25 min).
- Assign Final Quiz (20 min).

Other Suggestions

- Supplement with slides of real lagoons and real problems.
- Display examples of weeds and algae for microscopic and non-microscopic observation.
- Collect samples of influent and effluent to compare characteristics.
- Arrange a field trip to a lagoon to make the recommended visual observations. Have students measure D.O., pH and temperature on influent and effluent. Discuss potential flow pattern variations.
- Have samples of trend charts showing D.O., pH, and temperature diurnal fluctuations.

FACULTATIVE LAGOONS

Lecture Outline

Lesson I - Microbiology, Components, and Operational Modes

Slide #	Outline
#1.1 & #1.2	Title and Credit Slides
#1.3	Definition of facultative lagoon General structure General flow General statement of theory
#1.4	Outline slide - Microbiology
#1.5	Major groups of microorganisms that will be found in a facultative lagoon
#1.6	Vertical zonation - aerobic, facultative, and anaerobic
#1.7	Aerobic Zone Aeration of this zone accomplished by photosynthesis and wind action
#1.8	Food Supply Dissolved and suspended food enters system Dissolved food in aerobic and facultative zones, suspended in facultative and anaerobic zones
#1.9	Aerobic stabilization of food Bacteria consume food (nutrients) and oxygen to produce new cells and inorganic byproducts
#1.10	Photosynthesis is aerobic zone Algae consume inorganic nutrients and use sun's energy to produce new cells and oxygen

#1.11	Symbiotic interrelationship between bacteria and algae
#1.12	Dissolved oxygen concentration is a diurnal cycle
	Algae consume oxygen all the time but produce oxygen only during the day when the sun is shining
#1.13	Food supply to anaerobic zone
#1.14	Anaerobic stabilization
	Anaerobic bacteria consume nutrients and use chemically bound oxygen to produce new cells and by-products
#1.15	Organisms found in each zone
	Aerobic - algae, protozoa, and bacteria
	Facultative - protozoa, bacteria, and worms
	Anaerobic - bacteria
#1.16	Outline Slide - Components
#1.17	General appearance
#1.18	Dikes - material, slope, and depth
#1.19	Lagoon bottom - smooth, flat, leakage
#1.20	Inlets - edge, center, and multiple
#1.21	Outlet Structures -
	Surface or sub-surface
	Short circuiting
#1.22	Associated processes
	Meters, pre-treatment, and disinfection
#1.23	Outline Slide - Modes of Operation (Single and Multiple Cell)
#1.24	Multiple Cell - series and parallel

#1.25	Flow alternatives
	Flow recycle
	Flow transfer
#1.26	Flow alternatives with multiple cell systems
#1.27	Designs for controlling effluent flow
	Continuous
	Controlled
	No discharge
#1.28	Outline slide - Summary
#1.29	Summary of microbial stabilization
#1.30	Summary of components
#1.31	Summary of operational modes

Lesson II - Process Control and Maintenance

Slide #	Outline
#2.1 & #2.2	Title and Credit Slides
#2.3	Outline slide for Lesson II
#2.4	Factors affecting treatment - preview slide
	Natural, physical, and chemical
#2.5	Natural - wind
	Mixing, D.O., shortcircuiting
#2.6	Natural - temperature
	D.O. vs growth
#2.7	Natural - rainfall
	effects on detention time, concentration and volume
#2.8	Natural - sunlight
	penetration vs D.O.
#2.9	Physical - flow patterns and depth
#2.10	Physical - organic overloading
	low D.O., short detention time, and poor stabilization
#2.11	Series - Best for:
	warm climates lower loading reduced algae in effluent
#2.12	Parallel - Best for:
	cold weather higher loading distributing load
#2.13	When to use recycle and transfer flow patterns
#2.14	Chemical - D.O., nutrients, and pH

#2.15 pH - affected by the presence of carbon dioxide creating carbonic acid

#2.16 pH is depressed when bacteria respire because they release carbon dioxide

#2.17 pH is raised when algae consume carbon dioxide during photosynthesis

#2.18 Outline slide - Control Tests

#2.19 Respiration Rate vs. Photosynthesis

Control tests used to maintain balance so that pH does not change radically

#2.20 Sampling sites

Influent, effluent, and pond

#2.21 Sample for loading at influent

Record flow, run pH, BOD, suspended solids, and temperature tests

#2.22 Determine pond status by sampling in the pond itself

Run D.O., temperature, pH; observe microorganisms and run oxygen uptake test

#2.23 Determine effluent quality by sampling effluent

Run BOD, suspended solids, residual chlorine, fecal coliforms, and nitrogen and record flow

#2.24 Outline slide - Operations and Maintenance; Calculations

#2.25 Transition Slide - (Use to introduce calculations and move to overhead or chalk board)

#2.26 Outline slide - Operations and Maintenance; Observations, PM Program, and Recordkeeping

#2.27 Observations of pond conditions

Color, surface, weeds, and odor

#2.28	Observations of structural conditions Buildings, dikes, fences, and grounds
#2.29	Preventative Maintenance Pumps, grinders, meters, chlorinators
#2.30	Recordkeeping
#2.31	Outline slide - Problems
#2.32	Nuisances - weeds, insects, and odors
#2.33	Nuisances - dike vegetation and burrowing animals
#2.34	Problems in the pond itself Excessive algae growth
#2.35	Problems with effluent quality High BOD and suspended solids
#2.36	Summary of factors affecting treatment
#2.37	Summary of sampling

FACULTATIVE LAGOONS

Answers to Worksheet

1. The three vertical zones in a facultative lagoon are:

   aerobic

   facultative

   anaerobic

2. Oxygen is supplied to a facultative lagoon by wind and photosynthesis.

3. In the symbiotic relationship between algae and bacteria algae produce oxygen which is used by the aerobic bacteria. The bacteria produce carbon dioxide as a by-product which is used by the algae.

4. The only control parameter for a single cell lagoon is water depth.

5. A parallel flow pattern is used when there is cold weather, high loadings and to distribute load evenly.

6. A series flow pattern is used when there is warm weather, lower loadings and to reduce algae in effluent.

7. Cold temperatuares combined with short days will decrease microbial and algae metabolism.

8. The phenomenon of warm bottom water rising to the surface in the spring when the ice cover melts is called spring turnover.

9. When carbon dioxide accumulates the pH will decrease.

10. A sparkling green color usually indicates basic pH levels.

11. List the tests that should be performed on the pond influent.

    Flow
    pH
    BOD
    Suspended solids
    Temperature

12. List the tests that should be done on the pond effluent.

BOD
Suspended solids
Chlorine residual
Fecal coliforms
Nitrogen
Flow

13. List the tests that should be done on the pond itself.

D.O.
Temperature
pH
Oxygen Uptake Rate
Microorganism Observation

14. Calculate the organic loading rate for a lagoon with the following characteristics:

Length = 500 ft.

Width = 500 ft.

Influent BOD = 130 mg/l

Flow = 175,000 gal/day

Organic Loading, lbs BOD/day = Inf BOD, mg/l X Flow, MGD X 8.34

= 130 X 0.175 X 8.34

= 190 lbs BOD/day

$$\text{Surface Area, acres} = \frac{\text{length, ft X width, ft}}{43{,}560\ \text{ft}^2/\text{acre}}$$

$$= \frac{500 \times 500}{43{,}560}$$

= 5.74 acres

$$\text{Organic Loading Rate, lbs BOD/acre/day} = \frac{\text{Organic Loading, lb BOD/day}}{\text{Surface Area, acres}}$$

$$= \frac{190 \text{ lb BOD/day}}{5.74 \text{ acres}}$$

= 33 lb BOD/acre/day

15. Calculate seepage rate for the following conditions:

Influent	=	60,000,000 gal/yr
Effluent	=	57,500,000 gal/yr
Precipitation	=	26 inches/yr
Evaporation	=	16 inches/yr
Surface Area	=	250,000 sq. ft.

Convert everything to inch/day:

$$\text{Inf, inch/day} = \frac{60{,}000{,}000 \text{ gal/yr}}{250{,}000 \text{ ft}^2 \times 228}$$

$$= 1.05 \text{ inch/day}$$

$$\text{Eff, inch/day} = \frac{57{,}500{,}000 \text{ gal/yr}}{250{,}000 \text{ ft}^2 \times 228}$$

$$= 1.03 \text{ inch/day}$$

$$\text{Precipitation} = \frac{26 \text{ inch/yr}}{365 \text{ days/yr}}$$

$$= 0.07 \text{ inch/day}$$

$$\text{Evaporation} = \frac{16 \text{ inch/yr}}{365 \text{ days/yr}}$$

$$= 0.04 \text{ inch/day}$$

$$\text{SEEPAGE} = [\text{Inf} + \text{Prec}] - [\text{Eff} + \text{Evap}]$$

$$= [1.05 + 0.07] - [1.03 + 0.04]$$

$$= 1.12 - 1.07$$

$$= 0.05 \text{ inch/day}$$

FACULTATIVE LAGOONS

Name _____

Final Quiz

Multiple Choice: For each question select the best answer(s) and place an "X" in front of the appropriate letter.

1. Lagoon organic loading is expressed as:

____ a. lbs BOD/day
____ b. lbs BOD/ft^3/day
____ c. lbs BOD/acre/day
____ d. lbs BOD/1000 ft/day
____ e. lbs BOD/gal/min

2. A facultative lagoon system has three zones of treatment. These are: (choose 3)

____ a. aerobic
____ b. intermediary
____ c. facultative
____ d. anaerobic
____ e. extended

3. Oxygen in a facultative lagoon is supplied from two sources. These are: (choose 2)

____ a. algae
____ b. mechanical mixers
____ c. diffused air
____ d. wind and wave action
____ e. windmills

4. Subsurface withdrawal is beneficial as it:

____ a. allows the operator to draw off the water layer with less algae concentrations
____ b. allows the operator to draw off the bottom waters when 'spring turnover' occurs
____ c. allows the operator to exercise depth control
____ d. all of the above
____ e. none of the above

5. Single cell lagoons have only one process control parameter. This is:

___ a. mode change
___ b. flow
___ c. depth
___ d. algae control
___ e. weed control

6. Multiple cell lagoons have three possible treatment stages. These are: (choose 3)

___ a. secondary stage
___ b. tertiary stage
___ c. recycle stage
___ d. primary stage
___ e. anaerobic stage

7. Which treatment stage is similar to a primary clarifier and mixed liquor basin in an activated sludge plant?

___ a. recycle
___ b. secondary
___ c. primary
___ d. tertiary
___ e. anaerobic

8. Which stage is used for settling?

___ a. secondary
___ b. recycle
___ c. primary
___ d. tertiary
___ e. anaerobic

9. Which stage is used for algae removal and often nutrient removal?

___ a. secondary
___ b. recycle
___ c. primary
___ d. tertiary
___ e. anaerobic

10. Multiple cell lagoons also offer 2 modes of operation. These are: (choose 2)

___ a. parallel
___ b. recirculation
___ c. series
___ d. reaeration
___ e. stabilization

11. The mode usually used for higher loading conditions because it offers longer detention times in the primary stage and better distribution of solids is:

___ a. parallel
___ b. recirculation
___ c. series
___ d. reaeration
___ e. stabilization

12. "Spring turnover", a normal annual lagoon event,:

___ a. causes a sudden increase in effluent algae populations.
___ b. causes a sudden decrease in effluent turbidity.
___ c. causes a sudden increase in effluent turbidity.
___ d. has no significant importantance on effluent quality.
___ e. is a continuous event.

13. A rapid increase in temperature will temporarily:

___ a. result in a more turbid effluent
___ b. result in a clearer effluent
___ c. affect anaerobic metabolism
___ d. have no effect on lagoon treatment
___ e. none of the above

14. Higher DO's would be expected:

___ a. early morning
___ b. early evening
___ c. midnight
___ d. late afternoon
___ e. all day

15. An acidic pH condition can be corrected by:

___ a. copper sulphate
___ b. sodium nitrate
___ c. letting the cell rest for a few days
___ d. all of the above
___ e. none of the above

16. A yellowish-green lagoon appearance is indicative of:

___ a. an alkaline condition
___ b. an acidic condition
___ c. a healthy, normal lagoon
___ d. an excessive filamentous condition
___ e. the presence of blue-green algae and duck weed

17. During months high in algae concentrations heavy chlorination of the effluent will:

____ a. cause a decrease in BOD
____ b. cause an increase in BOD
____ c. cause an increase in TSS
____ d. have no effect on BOD or TSS
____ e. increase fecal coliform count

18. Odor control may include:

____ a. mode cnange to parallel
____ b. increase DO
____ c. masking agents
____ d. all of the above
____ e. none of the above

19. DO can be supplemented by:

____ a. sodium nitrate
____ b. aeration devices
____ c. recirculation of pond effluent
____ d. both a & b
____ e. all of the above

20. Cattails can be controlled most effectively by:

____ a. pulling in late summer after they bloomed and have colonized
____ b. lowering water level and cut when the flowering heads are 1/2 to 2/3 formed in early spring
____ c. lowering water level and allowing sheep or goats to graze
____ d. both b & c
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Name _____

Answers for Final Quiz

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